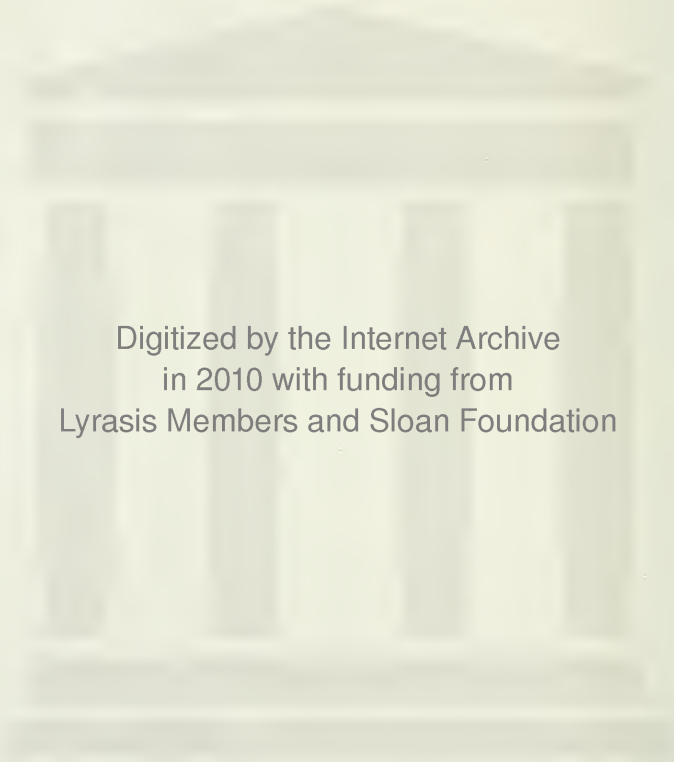

WEST VIRGINIA UNIVERSITY

AGRICULTURAL EXPERIMENT STATION,

MORGANTOWN, W. VA.

BULLETIN 70. NOVEMBER, 1900.

SPRAYING.

RESULTS OF THE SEASON, 1900.

BY L. C. CORBETT.

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No. 1's No. 2's No. 1's No. 2's No. 1's No. 2's

Sprayed four times. Sprayed twice. Not sprayed.

FIG. 1—Beauty of Kent.

No. 1's Not sprayed. No. 2's

Common Rambo.

First part of Fig. 2.

SPRAYING.

RESULTS OF THE SEASON, 1900.

Notwithstanding the fact that spraying has become a fixed practice with most commercial fruit growers, and that the general principles upon which its use and application depends are well understood, yet, as with all other practices, different localities demand special modifications of the spray used to adapt it to their peculiar needs. Then too, an art is always susceptible of improvement and since improvement in sprays or spraying methods means a saving in dollars and cents to the grower, it cannot but prove a profitable field for study and experiment.

I.—The work which we have to report at this time was undertaken for the purpose of acquiring some just basis for estimating the value of standard fungicides and insecticides now in use when faithfully applied by the orchardist.

A test was carried out in an orchard such as is usually found upon our better farms, an orchard of 2 to 3 acres, composed chiefly of dessert fruits, such as Grime's Golden, Rambo, York Imperial, Maiden's blush, Gilliflower, Spitzenburg, Beauty of Kent, etc.

II.—A second division of the work consisted of an attempt to find a combination of Contact and Poisonous Insecitctides with a Fungicide.

The first question was to find a machine for applying such a mixture; the second to determine upon a suitable mixture, and a third to study its action upon the foliage of trees as well as upon the insects and fungi treated.

III.—A test of some of the insecticides not now in general use, but which possess features which render them especially desirable for general spraying should they prove as efficacious as the standard insecticides.

IV.—A test of some of the newer remedies being brought forward for the control of the San Jose Scale.

THE VALUE OF SPRAYING.

The results here reported are from a comparison of sprayed and unsprayed trees of the same variety grown upon the farm of J. W. Guesman, Reedsville, W. Va. The orchard is about thirty years old, planted too thickly, the trees standing 33 feet apart, and until the spring of 1899, the orchard had been in sod for several years and little attention given to proper pruning. In the spring of 1899 the orchard was lightly pruned. The removal of dead wood and water sprouts constituting the chief part of the work. One half of the plat was then broken up and kept cultivated, the trees receiving a dressing of fertilizer along with the cultivation.

In 1899 the trees were sprayed regularly through the season although there was no crop. The first spraying of that year being made after the blossoms fell.

In 1900 the orchard was again sprayed with Bordeaux Mixture and Laurel Green, the trees receiving the same number of applications as in 1899, except that the whole orchard was sprayed with Bordeaux Mixture before the leaf buds opened. In addition to this early spraying, the trees received one, two, and three treatments respectively with Bordeaux Mixture and Laurel Green.

The dates of spraying were as follows: first application made April 19, second May 23, third June 8 and the fourth on June 23.

The following comparisons made between trees sprayed once before the leaf buds opened and those having one, two or three additional treatments thereafter, express only the value of the later treatments as compared with the one before the buds opened and not with sprayed and unsprayed trees. This comparison is important as it throws much light upon two disputed points, namely, when the most damage is done by

No 1's

Sprayed twice.

No. 2's

No. 1's

Sprayed four times.

No. 2's

FIG. 2.--Common Rambo.

the scab and the best time to treat it: and second the best time to spray for "Frog Eye" (*Phyllosticta pirina*)

The verdict of the fruit is given in the accompanying tables and photographs. see Fig 1. Beauty of Kent, and Fig 2. Common Rambo.

TABLE I.—BEAUTY OF KENT.

TREATMENT.	Per cent. Scab.	Percent not Scabbed.
1. Sprayed once before leaf buds opened.	84	16
2. " " " blossom " " after blossom fell	36	64
3. " " " before leaf buds opened " " blossom buds opened " 2 times after blossoms fell.	22	78

TABLE II.—COMMON RAMBO.

TREATMENT.	Per cent. Scab.	Per cent not Scabby.
1. Sprayed once before leaf buds opened.	50.5	49.5
2. " " " blossom buds opened " after blossom buds fell	32.2	67.8
3. " " " before leaf buds opened " " blossom buds opened " 3 times after blossoms fell.	31.9	68.1

TABLE III.—GRIMES GOLDEN.

TREATMENT.	Per cent. Scab.	Per cent not Scabby.
1. Sprayed once before leaf buds opened.	11	89
2. " " " blossom buds opened " 2 times after blossoms fell.	7	96

These results are very remarkable, first in revealing the large percentage of scabby apples in some varieties, and the comparative freedom from scab of others. The Beauty of Kent carried 84 per cent of scabby fruit: the common Rambo 50.5 per cent while Grime's Golden had only 11 per cent on trees sprayed once before leaf buds were out. Notwithstanding the small percentage of scab in the Grime's Golden the spray revealed its work upon the fruit in two ways: first in lessoning the percentage of scab from 11 to 7 upon a tree much less favorably situated. and secondly, by returning bright clean yellow fruit on the sprayed tree as against discolored sooty looking fruits on

the tree sprayed only before the leaf buds opened. This sooty look was very common upon all light colored fruits of the region this season. It is the result of a fungus which works upon the surface of the apple, deriving its chief sustenance from the oily secretions so characteristic of the skin of most yellow and green apples. This pest is known as (*Leptothyrium pomi*) or "Fly-speck fungus" of the apple. Fig 3. While this disease does not appear to affect the pulp of the fruit, it makes the surface very unattractive, and consequently not suitable for use on the table, or on train or fruit stands. The result above mentioned in connection with the Grime's Golden was equally as pronounced upon the Beauty of Kent. If the late sprayings accomplished nothing more than to protect the fruit from the "Fly speck" fungus, its use would be justified.

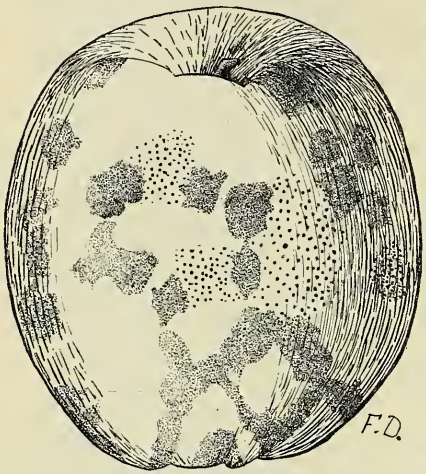

FIG. 3—"Fly-speck fungus."*

A second result, not observable from the tables, was the effect of the spray upon the length of time the foliage remained upon the trees in the fall. Both (*Phyllosticta pirina*) "Frog-eye," Fig. 4, and (*Fusicladium dendriticum*) "Apple-scab" Figs. 5 and 6. work upon the foliage, causing the leaf to drop early in the season, often as early as the last of August or the first of September.

The first named is common through nearly all of the apple growing regions of the State, and in the Fall of 1899, where not treated, caused a very serious loss to growers by preventing coloring and proper maturity of the fruit. The trees lost their foliage early, thus leaving the fruit exposed to the full force of the hot September sun, a condition not conducive to proper maturity or to good keeping qualities.

*From Ohio. Bull. 79.

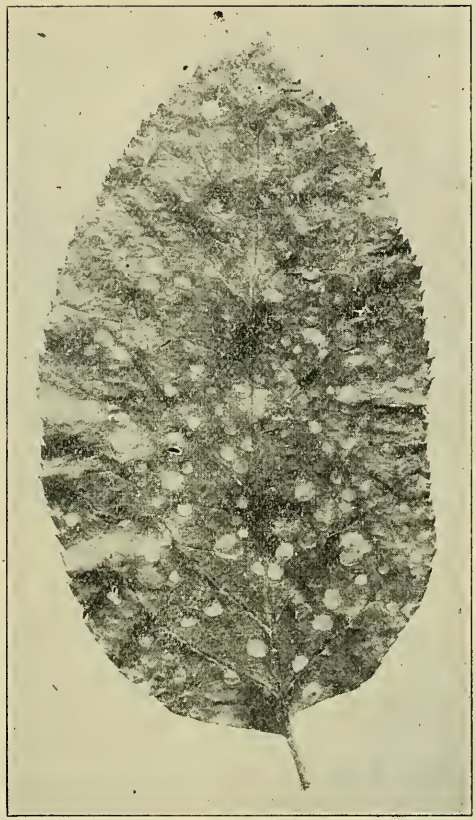

FIG. 4—Frog Eye.—From Bull. 66.

The results of spraying as a safeguard against the damage from these pests is shown in the accompanying photographs, taken on September 20th 1900. Fig. 7, showing a representative branch of a Grime's Golden tree, not sprayed after the leaf buds opened,, while Fig. 8 is a branch from a Grime's Golden tree sprayed four times, once before and three times after the leaf buds opened.

While the retention of the foliage in a healthy condition up to this date appears, at first thought, as a very trivial consequence, yet when it is remembered that the leaves are the work-

FIG. 5—Scab on Fruit, after Lodeman.

shop of the plant, through which all materials for growth of either branch or fruit, must pass before supplying the demands of that particular organ: it becomes evident that any thing which affects the leaves, directly affects every other part of the plant. The proper maturity of the fruit, the wood and the buds from which next seasons fruit crop is to be produced, all depend upon the condition of the foliage. Loss of foliage means premature fruit, imperfectly ripened wood, liability to injure by severe cold, because of a less resistent condition of the fruit buds, and a short crop of fruit the succeeding season. In reality the maintenance of the foliage means as much to the commercial grower as the protection of the fruit crop of a season.

FIG. 6—Apple Scab on leaf and fruit, from Bull. 66.

The gain in the number of fruits not affected by the scab

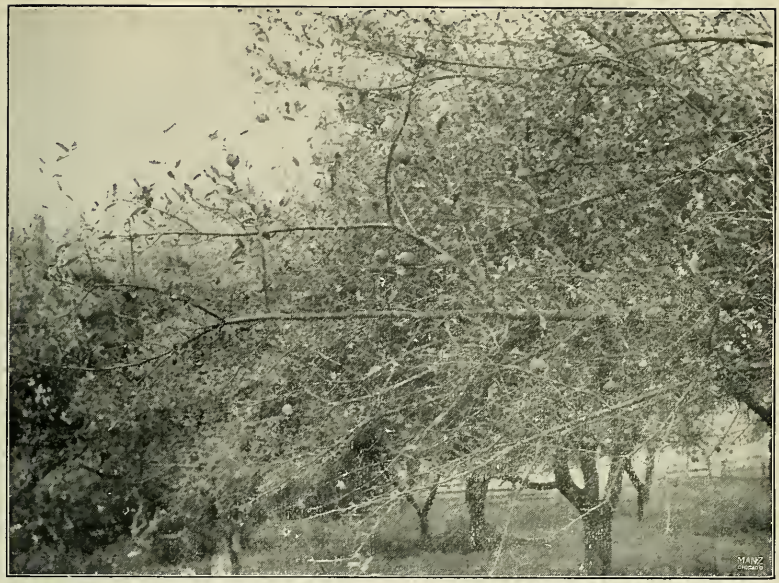

FIG. 7.—Grimes Golden.
Sprayed once before leaf buds opened.

FIG 8.—Grimes Golden.
Sprayed four times, once before leaf buds opened and three times thereafter.

shown as a result of the treatment of both the common Rambo. and Beauty of Kent are sufficient to warrant a grower in spending his time and money to spray his trees. In the case of two treatments of the Rambo. as reported in Table II., the quantity of good fruits was increased 18.3 percent or 18.3 bushels on every one hundred; while in the case of the Beauty of Kent the result from the use of the spray three times after the leaf-buds opened resulted in an increase of 62 per cent or 62 bushels out of every hundred. While these statements are almost incredible they do not express the whole truth for it is well known that sprayed trees often carry a fair crop when neighboring unsprayed orchards are barren. In other words a judicious use of the spray holds the fruit on the tree. When there is a light crop it is more imperative that spraying should be thoroughly carried on than during seasons of full crop, for with a heavy crop the loss will not be greatly felt, while with a sparse crop, which usually follows a season of heavy crop the greatly increased number of insects as well as fungi taken in connection with a reduced quality of material to breed upon, renders the liability to loss, as well as the task of treatment, much greater. Then too, as a rule, the off-year crop is worth much more per barrel than the full-season crop, hence the necessity for exerting extra efforts to maintain it.

If only three or four per cent. increase in the quality of merchantable fruit resulted from the use of Bordeaux Mixture, the more healthful condition of the trees would be sufficient to warrant the practice.

TREATMENT FOR THE CODLIN MOTH.

The insect causing the wormy apples which constitutes a great percentage of the "wind-falls", is known as the "Apple-worm" or "Codlin Moth". In this region the insect appears in several broods, the adult or parents of the first brood issuing in time to deposit their eggs upon the newly formed fruit soon after the blossoms fall; one and probably two or even three broods follow in this latitude upon the lower elevations where our most

extensive orchard belts are situated. The first brood is easily held in check by the use of Paris Green or London Purple applied with the spray immediately following the falling of the blossoms, this and the spraying generally made ten days later, are the only ones in which the poison is usually recommended. With us, however, it is evident that the poison must be used much later, probably as late as the middle of July. This question is being studied but not enough evidence is at hand to justify a conclusion.

Insecticides—In this connection it will be of interest to state our experience with new insecticides.

Laurel Green used in combination with Bordeaux Mixture.

TABLE IV.—COMMON RAMBO.

TREATMENT.	Per cent. Wormy.	Per cent. not Wormy.
No treatment	17	83
Sprayed twice with 12 oz Laurel Green to 100 gal. of spray	19	81

The above table shows that 12 oz. of Laurel Green to 100 gallons of the Mixture was not sufficient to decrease the number of wormy apples on the sprayed trees below those on the unsprayed trees.

Paris Green Treatment.—A single application of 5 oz. to 50 gallons of the spray was made May 15. When fruits were examined at picking time in Oct. the unsprayed tree carried 16 per cent. of apples which had been attacked by an early brood of Codlin moths and 41 per cent of injury for the whole season, while trees sprayed but once, on May 15, showed 6 per cent of fruits carried were scarred by an early brood and 38 per cent of injuries for the whole season, see table V and Fig. 9.

TABLE V.—BEN DAVIS.

TREATMENT.	First Brood.	For Season.
Not sprayed	16 per cent.	41 per cent.
Sprayed May 15.	6 per cent.	38 per cen .

This table indicates the efficiency of Paris Green against the

No. 1's Sprayed No. 2's No. 1's Not sprayed. No. 2's

FIG. 9.—Ben Davis, result at close of season.

first brood and emphasizes the importance of applications later than May 15th.

Arsenate of Lead:—was used in connection with Bordeaux Mixture as a substitute for Paris Green, but as we have no table of results to show its efficiency in comparison with Paris Green, London Purple, etc., no further mention is necessary more than to state that it was made by dissolving 11 oz. of Acetate of Lead in one vessel and 4 oz. of Arsenate of Soda in another, which when poured together forms Arsenate of Lead, enough for 150 gallons of the spray. The chief advantage possesed by this poison over others in common use, is its very fine division and the fact that it remains a long time in suspension without agitation, a quality much to its credit for use in large power sprayers such as shown in Fig. (10) where agitation is expected to result from the rolling of the liquid in the semi-cylindrical tank by the motion it receives in moving over the rough ground of the orchard.

This material proved very satisfactory in treating the larva of a moth (*Ichthyura sp.*) which was feeding upon the Carolina Poplars about town, a single application being sufficient to destroy the caterpillars and without injury to the foliage. It was further noted that the poison adhered well even to the glossy leaves of the poplar.

COMBINATION OF CONTACT AND POISONOS INSECTICIDE WITH A FUNGICIDE.

Experiments carried on this season using 10 and 15 per cent. Kerosine with the standard Bordeaux Mixture containing an arsenical poison, have proven gratifying far beyond our most sanguine expectations. This combination was rendered possible by using the Kerosine in the oil tank of a "Kerowater Pump" and placing the Bordeaux and Arsenic in the barrel in the ordinary manner. This combination was used upon apple, pear and plum during the season. The first application being made April 26th to apple, pears and plums, one half of the trees being left unsprayed in every case. On May 12th the treatment

was repeated on all the trees receiving the application of April 26th. The following note recorded at that date.—"No injury from the use of the 10 percent. Kerosene to be detected at this time." On June 9, the spray was again used, 10 per cent. mixture repeated on trees formerly sprayed with it. On one apple tree badly infested with aphis and which had been sprayed with Bordeaux Mixture on April 26, a 15 per cent. Mixture of Kerosene was used.

Note, July 11, 1900. The one tree to which 15 per cent. Kerosene—Bordeaux Mixture was applied June 9, shows "no injury from the use of the oil." The aphids were all destroyed by this one application and none ever appeared upon the trees receiving the 10 per cent. Kerosene—Bordeaux Mixture from the first, although other trees not sprayed with the Kerosene were badly infested. In fact an unusually large number of letters reached us this season complaining of the abundance of the green aphis upon young and old trees alike.

If further tests of this mechanical combination of Kerosene with Bordeaux Mixture and a poisonous insecticide prove as successful as the work of the present season, we have an easy and effective means of controlling plant lice at trifling cost.

The expense of the Kerowater Pump or some other good mechanical device for combining Kerosene and water, added to that of the Kerosene oil is all that is necessary, as the expense for labor is the same whether the Kerosene is used or not.

MECHANICAL BORDEAUX MIXTURE.

This mixture was conceived for the purpose of preventing the ill effects resulting from the standing of Bordeaux Mixture after the combination of the lime and copper sulphate solutions, which make constant agitation necessary. To accomplish this the two solutions were prepared in the usual manner, except that a concentrated solution of copper sulphate was used instead of a dilute one. This consisted of 2 lbs. of copper sulphate in 4 gallons of water. Two pounds of lime was slaked and diluted with 12 gallons of water. The two solutions

Fig. 10.—Hand Power Sprayer.

were then placed in the two receptacles of a Kerowater pump; the concentrated copper sulphate in the oil tank, and the 12 gallons of lime water in the barrel. The pump was then set to make a 25 per cent. mixture which combined the lime and copper sulphate in equal quantities in the nozzle. In appearance this solution was an ideal Bordeaux Mixture. It distributed well, no clogging as a result of the combination of the lime and copper sulphate forming sulphate of lime. This precipitate was formed as the material passed through the discharge hose and as it was under a high pressure it gave no trouble in the nozzle. This solution was used upon apple and quince only. Its action so far as could be judged from the seasons tests are in every way equal to those of the standard Bordeaux Mixture. The only advantage possessed by it over the ordinary mixture is the lessoned liability to clog the pump and nozzle. It is mentioned in this connection merely to show the possibility of making Bordeaux Mixture in this manner. No superior merits are claimed for it as a fungicide over the regular Bordeaux Mixture.

TOBACCO—KEROSENE EMULSION.

For Rose Bugs.

The Rose Bug was very abundant over the State the past season and did considerable damage to early sweet apples, peaches, and pears. The adult insects taking advantage of any wound to the surface of a fruit as a feeding place. It was not infrequent to find a young peach the size of a normal peach seed so covered by the insects that the mass would be as large as a Black Walnut with the hull upon it. The outlook was that every apple, pear and peach would be destroyed and the trees defoliated. Fortunately, however, their stay was brief and many fruits escaped injury.

Fearing that the result might be more destructive than it really proved to be, an attempt was made to treat the adult insects for the purpose of destroying them and at the same time rendering the plants immune. For this purpose a rather novel decoction was used in the form of a Tobacco Kerosene Emul-

sion, which was made by combining the Riley Kerosene Emulsion (1 gallon Kerosene ½ lb. soap) with two gallon of tobacco tea, which after the emulsion was complete was diluted to 15 gallons by the addition of water.

This mixture was applied to the infested peach trees at the Station Farm with evidently little effect upon either the insects or the trees.

The foliage of one tree (variety unknown) showed small red blotches over the surface at various points, the result of injury to the epidermis by either the Tobacco Kerosene Emulsion or too strong a Bordeaux Mixture, but as none of the other trees treated showed injury, it is believed that this combination can be used with safety on a majority of plants.

A similar combination was prepared for farmers near by as well as for residents of the town who used it with success in ridding their plants of the pest. In general, however, I am of the opinion that sprays for Rose Bugs are of little avail, except where used to render the plants immune by making them distasteful as breeding and feeding places for the insect. The spray if directed upon the insect for the purpose of destroying it will have little effect because of the migratory nature of the insect during this period. Even if the plants were entirely rid of the insects by an applictaion of the spray, others might take their places in a few hours unless the spray at the same time made the plants distasteful to the insects. In this respect the Tobacco Kerosene Emulsion has no rival unless it be Whale Oil Soap, which I believe to be one degree more offensive than any other insecticide yet invented. Whale Oil Soap might be substituted for hard soap in preparing the Kerosene Emulsion and by adding the tobacco extract a most offensive combination effected.

SAN JOSE SCALE.

The San Jose Scale has been the subject of so much discussion among horticulturists and entomologists of late, that a technical description of it in a spray bulletin would be out of place, yet a mention of some of the gross characteriers by which the pest can be recognized seems necessary.

The San Jose Scale is a tiny sucking insect, living under a minute cap or tent, which is composed of a waxy subtsance secreted from the body of the insect itself. Since the insect is covered during the greater portion of its existance by this cap, called a scale, the external characters of the pest must be based upon the size and appearance of the cap or scale. As a rule it would take 13 to 15 of these scale caps, placed side by side, to cover an inch in length. The insect is correspondingly small and can, therefore, be studied carefully only with a glass of high magnifying power.

The outline of the scale is circular, slightly crowning and marked by a minute golden eye mark in the center. Old scales lose their bright, waxen color and golden center mark, and when large numbers of them are present on a branch it has an ashen grey color, and appears as though wood ashes had been dusted heavily over the surface. By drawing a knife blade flatwise over such a limb, if live scales are abundant, the knife blade will produce a very faint crackling noise and will be followed by moisture; while if the scales are dead, no moisture will appear. When the scales are scraped off with a knife, removing only the outer portions of the bark, the inner bark will present a purplish or reddish color.

While very young the insects are not protected by the armour above spoken of, but appear as minute golden yellow insects, free to move about over the surface of the host plant or to crawl upon any object present which may suit their fancy. It is by this provision in the life cycle of the insect that it is enabled to scatter itself over the surface of the host plant, as well as to secure means of dissemination from plant to plant through such

agencies as other insects and birds. The scale has no means of its own by which it can transfer itself from plant to plant, but by crawling upon the foot of a bird or upon the body of another insect, it can secure transportation to new quarters: where, after a few days the young insect selects its permanent home and secretes its protecting cap.

The breeding season in this State begins about June 1st, and continues until cold weather sets in, although the most active multiplication seems to take place during the months of June and July. Since each adult female is capable of laying a large number of eggs, which hatch immediately, and since each of the young in turn is capable of producing offspring within a week's time after birth, the scale population of a tree may increase at an almost incredible rate.

It would at first thought appear as though such an insect would be a comparatively easy foe to govern, but on account of its protective cover, and the rapid rate of increase over such a long period, its treatment becomes difficult, and confined to one season.

Treatment. if any, during the growing season, must be with penetrating oils or caustic solutions. Such materials are, as a rule, injurious to the foliage and young growth of plants, consequetly it is almost impossible to obtain a material strong enough to kill the scale. which will not injure the foliage of the plant.

The spray must be strong enough to kill the adult as well as the young, and unless the material comes in direct contact with the adult it will not kill it.

Spraying during the growing season is a hopeless undertaking, although it would seem to be just the time to do the work.

All treatments. aside from the "gas treatment," that have proven in any way effective against the scale have been made with caustic solutions, such as Whale Oil Soap or penetrating oils, such as crude petroleum or kerosene. while the plants were in resting or dormant condition.

SPREAD OF THE SAN JOSE SCALE.

The rate of spread of an insect of such destructive habits as the San Jose Scale gives an index to the destruction which we have to fear from it.

The first introduction of the pest was upon individual plants purchased for purposes of resetting. In one case a single tree was set in an orchard of about 400 trees. From that source of infection the whole block has in the course of seven years, become more or less thoroughly infested notwithstanding the repeated applications of remedial and preventive sprays. Not only has the block above mentioned become thoroughly infested and many trees entirely destroyed, but a younger plantation, several hundred feet away, is more or less contaminated at the present time. In other orchards under treatment the source of infection is not so well known, but from the present condition of affairs the contamination of stock much have been much more general than in the case above mentioned, although examinations made two years ago, revealed the "scale" only upon two or three isolated trees. Such examinations, however are not to be relied upon for it is seldom that the inspector has opportunity to carefully examine any considerable number of trees of a suspected orchard. It is easy therefore, to overlook the chief source of infection while yet determining the orchard to be infested.

Perhaps one of the most marked instances of the spread of the insect which has been noted in our State, came under my notice the present autumn. A tree standing 200 feet from the line of adjoining property and at least 1500 feet from any trees known to be infested with the scale, was found to be badly infested. This only emphasizes the necessity of eradicating all sources of infection. For in this case it is evident that the scale had been transferred at least one fourth of a mile. Just how this was accomplished no one knows, but the only possible ways which suggest themselves are either birds or insects, and most probably by birds as they have a longer flight than insects.

This revelation carries with it another very emphatic lesson. The only likely source of infection for the tree above mentioned was from a few trees only slightly infected with the "scale" and these ever since its discovery, have been carefully and conscientiously treated with the standard "Whale Oil Soap solution" thus showing that it is not necessarily the most infested orchards that are the chief menace but that slightly infested ones are equally dangerous. Then again the lack of complete destruction and almost impossibility of extermination by use of Whale Oil Soap treatment is apparent.

TREATMENT OF SAN JOSE SCALE IN BERKELEY COUNTY.

At the request of the Berkeley County Horticultural Society a series of experiments to determine the efficiency of certain insecticides for the destruction of the San Jose Scale were instituted in infested orchards in Berkeley county. The local Horticultural Society provided funds for the purchase of all materials used except the crude petroleum which was furnished by the Experiment Station. The writer superintended the preparation and application of the materials, beginning the work on March 28, 1900.

The infested orchards which were treated are situated near Martinsburg, Berkeley Co., on what is known as the Apple Pie Ridge, a section remarkably well suited both by soil and climate conditions to the production of high grade fruit. The trees infested with the Scale consisted chiefly of peach, apple, pear, Japanese and European plums. Following the decision of the committee which consisted of G. P. Miller, J. W. Wood and Alex Clohan, the following insecticides were used:

Whale Oil Soap, standard solution, made by dissolving 2 lbs. of Goods No. 3 Whale Oil Soap in each gallon of water.

Dilute Kerosene 150 degree test illuminating oil was used as a 25 per cent. mechanical mixture with water.

Pure Kerosene—A treatment was made in which the above

mentioned 150 degree test oil was used without admixture of water.

Crude Petroleum.—A 20 per cent. mechanical mixture of crude petroleum and water was also used.

PREPARATION OF MATERIAL.

Whale Oil Soap.

The cost of preparing a spray mixture is often a very large element in the actual cost of the work of spraying; this is true to a marked degree in the use of whale oil soap. The preparation of a few gallons for experimental work or use upon a kitchen fruit plantation is a matter of small moment, but the preparation of a spray charge for a five barrel spray tank, such as is shown in Fig. (9) is quite another matter. In our work in the Berkeley county orchards, which was done the last days of March, it was found that the preparation of Whale Oil Soap to charge the spray tanks took as large a force of workmen and as much time as the application of the prepared solution. Large iron kettles holding from 6 to 15 gallons were hung over blazing (smoky) wood fires, the water pumped from a near-by well, and the "soap" removed from the large casks in which it was received with a long handled shovel, placed in large buckets and weighed in order to secure the proper 2 lbs. to the gallon. In this proportion it was necessary to bring the contents of the kettle nearly to the boil ing point in order to effect a perfect solution of the soap although it appeared livery and quite soft on being removed from the barrel. After being heated and dissolved the preparation was strained through a wire gauze before being placed in the spray tank. As the liquid had to be dipped from the kettles and carried in buckets to the spray tank one can conceive that the work of preparing 20 or 25 barrels of Whale Oil Soap solution is no small task. When completed each gallon of the solution had cost 8 cents, not counting labor of preparation which would add a fraction more.

None of the other mixtures required special preparation as

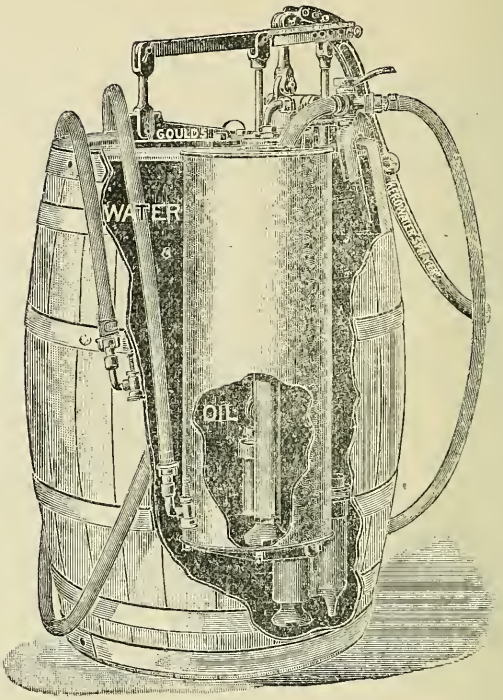

FIG. 10.

the mechanical mixtures of both Kerosene and crude petroleum were effected by the use of the Kerowater pump illustrated in Fig. (10). This pump while especially designed for making a mechanical oil and water emulsion and conceded to be the best on the market is not entirely satisfactory in its work either with kerosene or crude petroleum.

In our work, as soon as the trees dried, it was noticed that there was a very uneven distribution of oil over the body and branches. That this uneven distribution of oil was due to lack of action on the part of the oil lifting pump, or to the collection of oil in the discharge hose so as to produce a periodic flow of oil, is certain as the work of application was made under very favorable conditions, with new machinery and with more than ordinary care. As is suggested above, the lack of oil in the

spray can not be detected while the work is in progress, and with kerosene detection after the trees dry is very difficult while with crude petroleum it is an easy matter as the oil leaves the bark greasy wherever it comes in contact with it. It was by this means that the fact above mentioned was first detected. While results of the use of the 25 per cent kerosene solution indicate that the same thing had happened in the work with that mixture, it must be remembered in this connection that oil is a very difficult fluid to handle under pressure, and that crude patroleum because of its tendency to coagulate in cold weather, is especially difficult to pump. While this faulty distribution resulted with the use of the oils, no such error was detected in the use of a like pump in making the mechanical Bordeaux Mixture mentioned on page 362 of this bulletin.

APPLICATION OF SOLUTIONS.

The Whale Oil Soap solution was applied with a double discharge pump, illustrated in Fig. (9), with two Vermorell nozzles on a T head attached to the end of each bamboo extension rod. The pump lifted and discharged the mixture perfectly and with good force making a mist-like spray. The one difficulty encountered was with hose connections. The short-shanked hose connections used by the trade on ordinary lawn hose are also used on most spray outfits. They are too short, leave too little surface of hose in contact with the hose connection, rendering it difficult to hold the hose connection in the hose when high pressure and oily or greasy mixtures are in use. It was only after securing a liberal supply of hose clamps such as are shown in Fig. (11,) that we were able to hold the rubber hose upon the attachments connecting them with the pump and extension rod. The same criticism applies to the ordinary hose couplings when kerosene and crude petroleum are used.

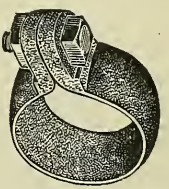

Fig. 11—Hose Clamp.

Mr. Janey, who made an extensive application of a heavy crude petroleum oil in February, mentioned the same difficulty

with the machinery. Besides the diffiiculty experienced with the machinery the nozzle-men as well as the pumpers and driver suffered personal discomfort from the mist of Whale Oil Soap sculution which is very disagreeable to smell and very caustic in its action on the skin of hands and face and almost unbearable if it falls in the eye or a wound. While the crude petroleum is not irritating in its effects, it is very greasy and unpleasant to handle during cold weather.

RESULTS OF THE SEASONS EXPERIENCE.

One of the first and most important factors to be determined in this work was the effect the various treatments were to have upon the plants themselves, and, secondly, the effect of the treatment upon the scale.

A visit was paid to the orchards treated for the San Jose Scale on May 16, 1900, when the following notes were made, "Inspection of the work done March 28 shows that neither the Pure Kerosene; 25 per cent. Kerosene; Whale Oil Soap or 20per cent. Crude Petroleum injured the leaf or fruit buds. Trees are at this time in a very thrifty condition, foliage normal, new growth about 6 inches long; blossom clusters still hanging and the young fruits which have set are as large as small marbles.

OBSERVATIONS ON THE SCALE.

Whale Oil Soap Treatment.—"Living scales found on the ends of twigs of trees treated with Whale Oil Soap. A few also on the larger branches of trees badly incrusted with the scale, but where a specially thorough spraying was made, a large precentage of the scales on those parts of the tree thoroughly covered by the spray are dead, probably 99 out of 100."

Oct. 12, 1900.—Trees most carefully treated on March 28, today show live scales of all ages upon all portions of the tree, whether grown since the spray was applied or not. The trees are little if any better off now than before the treatment was made. Scales present in small numbers on fruits borne on treated trees. There is absolutely no injury to the trees to be

Fig. 12.—Sprayed with Whale Oil Soap.

Fig. 13.—Sprayed with pure Kerosene.

detected from the use of Whale Oil Soap upon pear, apple, peach Domesitca and Japanese plums. See Fig. 12.

Pure Kerosene, May 16, 1900—"No injury to leaf or blossom buds. Trees set full of fruit and foliage in perfect condition. Trees not badly infested with scale before being sprayed. All scales on those parts of the tree thoroughly covered by the spray are dead."

Oct. 12, 1900—"No injury to trees from use of spray. No scales to be detected upon the plant, yet the fruits reveal their presence in small numbers." See Fig. 13.

25 per cent. Kerosene Treatment, May 16, 1900.—"Live scales found on badly infested trees. Trees thoroughly sprayed and only slightly infested show no live scales at this examination."

"Oct. 12, 1900.—"No injury to trees resulted, the bark of trunk, branches and small twigs even revealing no evidence of injury. Live scales found upon fruits borne by trees so treated as well as upon the branches of the same." The above treatment was confined to apple. peach and Japanese plum. See Fig. 14.

20 per cent. Crude Petroleum Treatment. May 16, 1900.—Both apple, peach and plum trees seem to thrive under this treatment. No fruit or leaf buds injured on any of the above mentioned plants. No live scales detected on trees well treated with the mixture.

Oct. 12, 1900—No injury to peach, plum or apple from the use of this mixture. The influence of this treatment on the scales not marked, live specimens found upon trees sprayed with this combination, new growths on badly infested trees showed a goodly number of young scales.

The bark on large limbs well treated with the mixture still showed the glossy surface characteristic of the treatment and while live scales were found on such branches they were always in protected places such as under scales of the bark, (on the apple) See Fig. 15.

Undiluted Crude Petroleum.—This material was used only

in a small way in our tests. It was, however, used on badly infested Japanese Plum trees without injury to the bark of the tree or to fruit or blossom buds. The treatment being made April 3d.

On Oct. 12th, the trees were in perfect health and the oil still gave the trees a bright clean appearance as though recently cleaned and oiled. Close inspection proved that the oil still remained despite the exposure to the elements for six months. But what is most gratifying of all is that thoroughy incrusted areas show no live scales either of this season or last sason's broods. In other words areas given a single treatment with undiluted crude Petroleum are immune to the scale at least eight months. The young scales even though abundant on parts not treated, are unable to establish themselves upon treated areas, and all old scales are killed by an application of the oil. The material while penetrating in its effect upon the scale is not capable of spreading itself over the surface of the bark even during the warm days of summer, hence the caution that every portion of the plant that is infested or liable to infection, must be coated with oil in order to render it safe from an attack of the scale. See Fig. 16.

Experience of Others.—Another orchard which was not included in the above test was sprayed with undiluted crude Petroleum by the owner during the month of February. This orchard has been made the subject of close observation along with those treated under the direction of the Berkeley Co. Hort. Society. The treatment in this case was with a heavy crude oil obtained from the Atlantic Refining Co. In cold weather such oil becomes thick and livery, which greatly militates against its use as an insecticide, as it is very difficult to force it through the nozzles. In this case a Nixon Pump and Vermorell nozzle was used, but great difficulty was experienced during the cold days of February to get the material upon the trees in anything like a satisfactory manner. Even with most painstaking work many areas, especially the underside of the lower limbs, escaped a coating with the oil. Limbs two inches in diametre showing

FIG. 14.—Sprayed with 25 per cent. Kerosene.

FIG. 15—Sprayed with 20 per cent Crude Petroleum.

a thorough coating of oil on the upper side would be found to present an area running along the underside, sometimes 2 or 3 feet in length, which had escaped treatment. In all cases the treated areas were found to be perfectly free from live scales in May as well as in Oct. when observations were made.

This gives conclusive proof that the spray is effective against the scale, and that the entire surface must be covered in order to make the work effective as the oil will not run around and cover the limb although heavily sprayed upon the upper surface.

Many instances were noted where a branch 1½ inches in diameter, well sprayed on the top side and perfectly free from living scales on Oct. 13, carried a line of bark on the under side which had not been covered by the spray, upon which great numbers of living scales, in all stages of developement, were to be seen.

Our observation in June, soon after the young scales began to move about, revealed hundreds of dead scales upon the oily surface of the treated areas, thus showing that the oil thrown on the branches in February still contained qualities making the migration of scales to treated areas impossible. In October skins of dead scales were not as numerous upon the treated areas, yet none had succeded in establishing themselves on the oil-coated portion.

Everything considered, the undiluted Crude Petroleum treatment has given the most promising results of any material that has so far, come under my observation.

One of the drawbacks to the use of crude petroleum as an insecticide at the present time, is the exorbitant price charged for it by the Refining Companies.

If it prove to be as valuable an insecticide as the tests of the season would suggest, an effort should be made to secure the product of some region which is known to produce an oil suited to this work. I make this statement because our experience convinces us that the heavy dark oils, which are upon the market as lubricating oils, and which are valued much higher

than the light amber oils of other fields, is the material which was sold to one of our friends and which proved so difficult of application, while no complaint came from those using the lighter grade oils, which is the more common product and sells for at the most one third of the price of the other.

"ORIGIN OF PETROLEUM AND BITUMEN.*"

"We have seen that the whole petroleum and bitumen series may be made artificially by destructive distillation of coal. There seems also to be little doubt that certain organic matters at ordinary temperature, in presence of abundant moisture, and out of contact of air, will undergo a species of decomposition or fermentation by which an oily or tarry substance, similar to bitumen, is formed. In the interior of heaps of vegetable substances such bituminous matter is often found. Taking the composition of petroleum as $C_n H_{2n}$, the reaction by which it is formed from vegetable matter is expressed in the following:

Cellulose..... $C_{36} H_{60} O_{30}$

Subtract { 15 $C O_2$ / 9 $C H_4$ ..... $C_{24} H_{36} O_{30}$

$C_{12} H_{24}$ petroleum.

Or,

Cellulose..... $C_{36} H_{60} O_{30}$

Subtract { 12 $C O_2$ / 6 $H_2 O$ ..... $C_{12} H_{12} O_{30}$

$C_{12} H_{24}$ petroleum.

There are therefore, two general theories of the origin of petroleum: one that it is produced by the distillation at high temperature of bituminous coal by volcanic heat, the coal being left as anthracite: the other, that it is formed at ordinary temperature by a peculiar decomposition of certain organic matters. The evidence in favor of the first view is the similarity between the artificial and the natural series; the objection to it is that the occurrence of petroleum seems to have no necessary connection with the occurrence below of coal-seams, and also

*Le Conte—Elements of Geology.

FIG. 16—Sprayed with undiluted Crude Petroleum.

FIG. 17—A tree weakened by San Jose Scale.

that petroleum is found mostly in strata which have not been subjected to any considerable heat.

The argument for the other view is the fact that we actually find fossil cavities in solid limestone containing bitumen, evidently formed by decomposition of the animal matter. So, also, shales have been found in Scotland filled with fishes, which have changed into bitumen.

The most probable view seems to be that both coal and petroleum are formed from organic matter, but of different kinds and under slightly different conditions—that coal is formed from terrestial vascular plants, in the presence of fresh water, while bitumen and petroleum are formed from more perishable cellular plants and animals, in the presence of salt water. We have already noticed the frequent association of petroleum and salt.

Origin of Varieties.—However formed there can be no doubt that the different varieties of this section are formed from one another by a subsequent process. It is certain that from all varieties $C H_4$ (marsh-gas) is constantly passing off, and that the result of this is a slow consolidation. By this process light oil is changed into heavy oil, heavy oil into bitumen, and bitumen into asphalt. Some of the grandest fissure reservoirs of oil have thus been changed into solid asphalt. In the upper barren coal measures of West Virginia there is a vein of asphalt four feet thick, over 3,000 feet long, and of unknown depth. It fills a great fissure which breaks through the rocks nearly perpendicular, and outcrops on the surface..

There are, therefore, two series of substances formed from organic matter, viz: the coal series and the oil series. In each series the proportion of carbon increases by subsequent change until, perhaps, pure carbon may be reached. In the coal series we have fat coal, bituminous coal, semi-anthracite, anthracite, and finally, graphite. In the oil series we have a light oil, heavy oil, bitumen, asphalt, probably jet, and possibly, finally, diamond; for Liebig has suggested that diamond is most probably formed by crystallization of carbon from a liquid

hydro-carbon, in which the proportion of carbon is constantly increasing by loss of C H_4."

From what we have stated it is evident that petroleum is a direct product of the decomposition of organic matter, animal or vegetable and is composed of carbon and hyrdogen, both of which are essential to plants, and carbon is chiefly found as a product of modified plant tissue. Since this oil is a direct product of plants it is the most natural result possible that it should prove to be a harmless spray for plants.

The efficiency of the material as an insecticide which is without injurious effect upon the plant while in a dormant condition, has been demonstrated beyond doubt. It yet remains to determine the effect of the spray upon growing plants, to learn the concentration which may be used and the character of the oil which will prove least objectionable to the user, and at the same time meet the requirements of an insecticide.

These are the problems we have in hand for the work in 1901.

This season's experience has demonstrated the efficiency of the oil and has brought out the difference in the various grades as well as proving that it can be used late in the season, on mild days, with greater ease, and with equally good results, as when used in cold weather, when it is so difficult to pump, and to force through the nozzle.

A study of the various oils produced in our State reveals a vast divergence in character, both as regards color and consistency, as shown by specific gravity tests.

The following, from Vol. 1. of the W. Va. Geological Survey, pp 374-377, will serve to illustrate this.

"CHARACTER AND QUALITY OF WEST VIRGINIA PETROLEUM."

"All of the oil produced in the State belongs to the highest grade and quality of Pennsyvlania petroleum of the "white sand" type. It has a paraffine base instead of asphalt as in Russian and most foreign oils, as well as in that from California,

Wyoming, Colorado, Texas, and all regions yielding petroleum from rocks of recent geological age, since the paraffine oils appear to be confined almost exclusively to rocks of the Palaeozoic Era.

The color of the West Virignia petroleum ranges from almost black through all shades of green and amber up to a nearly transparent fluid with only a tinge of yellow, while the gravity varies from 28 degrees B., a good quality of lubricating oil, occurring in the "Salt Sand" of the Volcano region, Ritchie county, at a shallow depth, to 63½ degrees B., the highest gravity petroleum known in the world, found in the First Cow Run Sand, near Moundsville, Marshall county.

Mr. H. L. Scrafford, General Manager of the Eureka Pipe Lines in West Virignia, has kindly given me a statement of the gravity, color, etc., of the oils from different sands in West Virginia and the adjoining regions of southeastern Ohio, as handled by the pump stations in the several regions. These oils would show a little higher gravity if the samples had been taken direct from the wells, but those given are the gravities of the several oils after they have been transported to the different local pump stations, and hence represent them on a commercial basis. This table which often includes several samples in the same region is as follows:

Location of Pump Station.	County.	Sand.	Gravity, o 's B.	Color.
Mt. Morris	Greene, Pa.	Big Injun	46	Amber
" "	" "	Dunkard	42	"
" "	" "	Elizabeth, Sixth	41	"
Dolls Run	Monongalia	Big Injun	46	"
Jakes Run	"	" "	46	"
Basnett, Fairview,	Marion	Gordon	43½	"
" "	"	Big Injun	45¾	"
Downs, Mann'gton	"	Gordon	42¾ to 43½	"
" "	"	Big Injun	46½	"
Tetrich	"	Gordon	42½	"
Joetown	"	"	42¾	"
Masters, Boa'd Tree	Greene, Pa	"	42½	"
Glendale	Mar-hall	First Cow Run	63½	"
Arches	Wetzel	Dunkard	52½	"
"	"	Big Injun	45¾	"
"	"	Gordon	39¼	"
Braden, Indian Cr.	Tyler	Big Injun	47¼	"
" "	"	Gordon	44¼	"
Big Flint	Doddridge	Dunkard	48¼	Black
" "	"	Maxton	45	Amber
" "	"	Big Injun	42¼	Black
" "	"	" "	43¾	"
" "	"	" "	46½	"
" "	Harrison	Fifth McDon'ld	44	"
Ankrom Indian Cr.	Tyler	Maxton	45½	"
" " "	"	Big Injun	48	"
Martin, Elk Fork	"	Keener	49¾	Amber
Wick	"	Cow Run	47	Green
"	"	Maxton	47	Black
"	"	Keener	45	Amber
Stewa't, Mid'eIs Cr	"	Cow Run	54	"
" " " "	"	Maxton	44	Black
" " " "	"	Keener	53¾	Amber
" " " "	"	Big Injun	44½	"
Corning	Athens, O	Berea	38	Black "

NOTE.—In reading the above table one must bear in mind that an oil listed as 38 degrees Baume in the table actually has a specific gravity of .8391 while an oil registered as 60 degrees has a specific gravity of .7449; the oil with the lowest reading is therefore the heaviest oil approaching nearest the density of water while that registering highest is less dense than water and consequently a lighter oil. Specific gravity therefore spoken of in terms of Baume gives an inverse scale.

From this it is evident that not only will the purchaser be confused by variation of color in the crude oil that comes to his hand but he will find corresponding differences in the facility with which the various products lend themselves to his work.

The lighter oils, those possessing the highest specific gravity, contain the smallest percentages of fats and waxes, which coag-

ulate at a high point: that is, substances which, when exposed to the cold render it stiff, livery and difficult to pour: while, on the other hand, oils with a low specific gravity contain more fats and wax which tend to make it more difficult to handle. In purchasing oils, therefore, it should be the aim to get those of high specific gravity. In this respect the West Virignia and Pennsylvania oils are superior to the heavy oils of the Corning class. The Pennsylvania and Eureka oils generally are, therefore, to be preferred from a mechanical point of view.

A SUGGESTION.

The use of "crude petroleum" as an insecticide has, in a majority of cases proven successful. But the term "crude petroleum" is a very uncertain one, as in one section of the country it means mineral oil of a certain color and composition, while in another section it refers to something entirely different.

In fact, the specific gravity above referred to, and which is used as a basis for all commercial valuations of crude oil, is variable, and merely indicates probable composition of the oil. Yet the physiological effect of an oil upon vegetation must be based on actual composition. For these reasons we can never hope to secure uniform results from the use of such a variable material. Our experience in the use of "crude oil" leads us to the conclusion that satisfactory results along this line will only come from the use of mixtures made from substances of uniform composition combined in definite proportions.

As an insecticide "crude petroleum" seems to be superior to "kerosene" only in that it carries with it vaseline and paraffine, which leave a coating of non-volatile material over the surface of the plant. This coating protects the plant against the scale and other insects. The idea of using a solution of a definite quantity of vaseline or paraffine in kerosene has suggested itself as a possible solution of these perplexing problems. By using a given solution of vaseline and kerosene, we may find a material containing all the good qualitis of crude oil and kerosene,

and at the same time secure a solution whose proportions may be varied so as to meet the physiological requirements of any fruit. To illustrate: a peach may require a certain amount of vaseline, while an apple may need a very different proportion to secure desired results. In a material of this sort we have the advantage of having substances of constant composition, so that as soon as the requirements of a particular plant shall be determined, a mixture can be made to suit these requirements, and when used will be certain to give success.

At present "crude petroleum" holds out no such inducements, and on the other hand often proves a difficult material to handle during cold weather. Along this same line, an altogether new field opens, for we may find it necessary to add the paraffine or vaseline only at certain seasons. Then, too, other of the more volatile petroleum products may come in as a solvent for vaseline or some of the amorphous waxes at certain seasons when crude oil could not be used, because of its behavior during the cold winter months.

This problem is at present engaging our attention along with the physiological effects of unmixed crude oils of known specific gravity.

L. C. Corbett.

Nov. 1, 1900.